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ISSN 0792 - 156X

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PUBLISHER:
Israeli Journal of Aquaculture - BAMIGDEH -
Kibbutz Ein Hamifratz, Mobile Post 25210,
ISRAEL
Phone: + 972 52 3965809
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Field Report

Experimental Commercial Growout of *Penaeus semisulcatus* (Decapoda: Penaeidae)

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(Received 7.6.06, Accepted 25.11.06)

Key words: *Penaeus semisulcatus*, growout

Abstract

Sea bass and sea bream have become almost synonymous with marine aquaculture in Turkey, indicating the level of commercial success they have attained during the last two decades. However, to diversify an industry overly dependent on these two products, as well as to provide the market with an additional commodity, other species are being considered for future culture. In the present study, commercial culture of *Penaeus semisulcatus* on the Aegean coast of Turkey was evaluated. In 150 days, the shrimp grew from 0.03 g to 18.72 g, with a mean daily growth rate of 0.125 g. The food conversion rate and specific growth rate were 2.26 and 2.34, respectively. Production reached the equivalent of 2880 kg/ha with a survival of 77%. While production results and shrimp weights were considerable, to obtain larger shrimp of greater value, early maturation and spawning in a nursery system must be included in conjunction with the growout ponds.

Introduction

Shrimp culture has been tested as a means of diversifying and broadening the scope of the aquaculture industry in growing areas and markets. In Turkey, shrimp production began as a capture fishery. The annual shrimp production in 1986-2003 from Turkey's Mediterranean, Aegean, and Marmora coasts averaged 3,663 tons, less than 1% of Turkey's total fish and shellfish landings (Memis et al., 2002; SIS, 2003). Although very profitable internationally, shrimp culture is still largely untested in Turkey. The first commercial shrimp hatchery and farm (Palmar) was built in 1995 in the Manavgat area of the Antalya

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Gulf to market fresh produce on the local and European markets and live hibernating shrimp to the Japanese market. However, the farm went bankrupt in 1998 due to financial and managerial problems arising from inadequate site assessment (Turkmen, 2001).

Penaeus semisulcatus, the most commercially important shrimp species, is an Indo-Pacific species distributed along the coast of the eastern Mediterranean and caught by Turkish, Israeli, and Egyptian trawlers (Holthuis, 1980; Kumlu and Eroldogan, 2000). The species has been the focus of laboratory and field research in Turkey (Aktas and Kumlu, 1999; Kumlu et al., 1999; Aktas et al., 2003, 2004; Kumlu and Kir, 2005), Kuwait (Kneale et al., 1981), Taiwan (Liao and Chao, 1983, 1987), Italy (Lumare et al., 1999), and, mainly, Israel (Samocha and Lewinsohn, 1977; Issar et al., 1987; Seidman and Issar, 1988). Kumlu et al. (2003) performed a study on the eastern Mediterranean coast of Turkey that dealt with commercial stocking rates.

Aegean aquaculture is dominated almost exclusively by sea bass and sea bream. To diversify, a shrimp culture test was carried out in 100 m^2 ponds on a marine fish farm in Izmir. Results indicated better growth performance in *P. semisulcatus* than in *Marsupenaeus japonicus* in the same culture conditions (Turkmen, 2005). The present study was conducted to determine the growth performance of *P. semisulcatus* on a commercial scale.

Materials and Methods

The study was conducted in a private marine fish farm (Pinar Sea Products) in Ildir, Izmir, Turkey. Mature *P. semisulcatus* females were transferred from Antalya to the farm hatchery for spawning. The spawned eggs were reared in hatchery conditions to the PL_{25} stage (25-day-old postlarvae). The postlarvae were stocked into one earthen 2000-m^2 pond (1.2 m depth) at a density of 20 PL/m^2. The pond was provided with filtered 37 ppt sea water, fresh water, and four 1-hp paddlewheel aerators. Urea and triple super phosphate (TSP) were used to maintain adequate transparency. Water exchange rates were 5-20% daily throughout the study (from June 13 to November 10, 2005). Dissolved oxygen and temperature were measured daily at 8:00 and 16:00, turbidity and pH daily at 16:00, and salinity weekly.

A commercial pellet shrimp feed for *P. monodon* (Pinar Feed Corp.) was broadcast by hand one to four times a day. Shrimp were sampled every fifteen days and individual weights were measured to the nearest 0.01 g. New feed rations were determined by using calculated mean wet weights, theoretically decreasing survival rates for estimated pond biomasses, and feed consumption checked on immersed feeding trays. Shrimps were harvested after 150 days by totally draining the pond and handpicking the shrimps from the pond bottom.

A linear growth model was determined using regression analysis of the shrimp weight and the number of days of growth. Weight increase was described as specific growth rate (SGR; Arnesen et al., 1994) according to the following equation: $SGR= 100[(\ln P_2 - \ln P_1)/(t_2 - t_1)]$ where P_1 and P_2 are shrimp weights at times t_2 and t_1. The food conversion rate (FCR) = weight of pellets fed/weight of shrimp produced. Results were compared with other studies of *P. semisulcatus*.

Results

Water temperature ranged 18.5-31.5°C. Continuous aeration and water exchange kept the dissolved oxygen levels above the minimum suggested for optimum growth in other penaeids (Seidman and Lawrence, 1985). Salinity ranged 32-40 ppt, similar to the optimal salinity of 30-35 ppt reported for *P. semisulcatus* by Kumlu et al. (1999). Secchi disk measurements ranged 30-70 cm and pH 8.0-9.4.

The shrimp grew from 0.03 g to 18.72 g in 150 days at a mean growth rate of 0.125 g/day (Table 1). The daily growth rate was lowest during the first and last 15-day periods when the mean water temperatures were low (23.9°C at 8:00 and 19.7°C at 16:00) and highest when the mean temperature ranged 26.0-29.5°C (Fig. 1). SGR was highest at the beginning of the study and lowest at the end.

Table 1. Results of growout pond trial for *Penaeus semisulcatus* in Izmir, Turkey.

Period (days)	*Feed rate (% body wt)*	*Wt at end of period (g)*	*Survival at end of period (%)**	*Growth (g/day)*	*Food consumption (kg)**	*FCR*	*SGR (%/day)*
Initial	-	0.03	-	-	-	-	-
0-15	Ad libitum	0.79	97	0.051	-	-	-
16-30	7	1.92	94	0.075	40.50	0.95	5.91
31-45	6	3.58	91	0.110	73.38	1.22	4.15
46-60	5.5	5.96	89	0.158	128.80	1.52	3.40
61-75	5.0	8.28	87	0.154	180.50	2.24	2.18
76-90	4.2	11.48	85	0.213	232.90	2.14	2.18
91-105	3.5	14.36	83	0.192	242.40	2.53	1.49
106-120	2.5	16.12	81	0.117	178.12	3.13	0.77
121-135	2.2	17.68	79	0.104	162.20	3.29	0.61
136-150	2.0	18.72	77	0.069	108.60	3.40	0.38
Mean	-	-	-	0.125	-	2.26	2.34

* Initial stocking was 40,000 postlarvae in a 2000-m^2 pond.

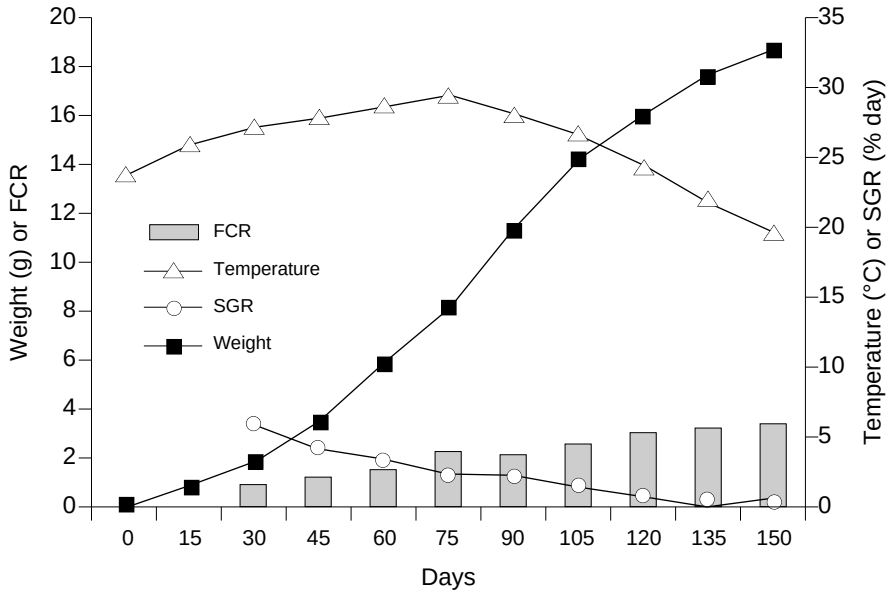

Fig.1. Growth of *Penaeus semisulcatus* in comparison to feed conversion ratio (FCR), water temperature, and specific growth rate (SGR).

Final extrapolated pond production was 2880 kg/ha with 77% survival. Regression analyses of shrimp weight in relation to time revealed a highly significant ($p \leq 0.0001$) linear pattern. The growth equation was $W = 4.06 + 0.151T$ ($r^2 = 0.98$).

Discussion

Production was 2880 kg/ha, higher than in most other locations (Table 2). Survival was good, 77%, and the FCR was 25% lower than in some other studies on *P. semisulcatus* culture. The fact that we were able to adjust the feed rate by observing uneaten food in the feeding tray might account for the lower FCR. Another factor may be that shrimp feed was used in this study while fish feed was used in others (Kumlu et al., 2003; Turkmen, 2005)

Shrimps grow only from early spring to late autumn on the Aegean coast of Turkey and have to be harvested before the cold season, allowing for only one crop a year (Seidman and Issar, 1988; Kumlu et al., 2003; Kumlu and Kir, 2005). During the first month of the study (June), the SGR was high but it dropped to its lowest at the end of the rearing period (November). Below 23°C, the growth rate decreased. Similar results were reported by Lumare et al. (1999) and Kumlu et al. (2003). The optimal temperature for *P. semisulcatus* was reported to be 28-30°C (Kumlu and Eroldogan, 2000). The highest daily growth rate in our study was 0.213 g, similar to that reported in Turkey by Kumlu et al. (2003) and in Israel by Issar et al. (1987) and Seidman and Issar (1988). The growth equation was similar to those of other studies on *P. semisulcatus* (Table 3).

The final weight in our study (18.72 g) is lower than required in the market for premium prices. A higher market size probably could have been obtained if shrimps of a higher initial weight were used (Seidman and Issar, 1988). Maturation and intensive nursery systems using greenhouses in winter extend the growout period by one to two months (Kumlu and Eroldogan, 2000; Aktas et al., 2003). The results of this field report suggest that yields in commercial shrimp culture in Turkey could be enhanced beyond those reported so far.

Table 2. Comparison of results from this study with those of other studies on *Penaeus semisulcatus*.

Reference	*Days (no.)*	*Survival (%)*	*Stocking density (no./m²)*	*Initial wt (g)*	*Final wt (g)*	*Yield (kg/ha)*	*Growth (mg/day)*	*FCR*	*Water temperature (°C)*	*Salinity (ppt)*
Present study	150	77	20	0.03	18.7	2880	125	2.26	18.5-31.5	32-40
Samocha and Lewinsohn, 1977	100	-	3	0.01	11.7*	-	116	-	17-37	38-50
Issar et al., 1987	162	45	8	0.17	21.0	739	124	9	22-32	42-45
Issar et al., 1987	101	5	20	0.001	22.7	227	259	10	22-32	42-45
Seidman and Issar, 1988	105	87	16	8.58	21.5	1600	123	4	18-29	40
Seidman and Issar, 1988	140	97	30	8.0	25.6	5039	125	3.1	18-29	40
Lumare et al., 1999	101	81	2.8	0.135	21.6	482	212	1.6	14.5-28	23-31
Kumlu et al., 2003	180	60	10	0.60	17.3	1038	110	3.15	19-31.5	40-41
Turkmen, 2005	150	82	15	0.03	15.6	1920	103	3.28	17.2-32.8	37-44

* females only

Table 3. Comparison of growth equations obtained in various studies for *Penaeus semisulcatus* (≥3 g).

Study	*n*	*Growth equation*	r^2
Present study	8	W = 4.06 + 0.151T	0.98
Kneale et al., 1981	8	W = 1.92 + 0.138T	0.95
Liao and Chao, 1983	10	W = 3.01 + 0.115T	0.99
Issar et al., 1987	10	W = 3.40 + 0.122T	0.97
Liao and Chao, 1987	9	W = 5.17 + 0.148T	0.99
Seidman and Issar, 1988	19	W = 3.12 + 0.150T	0.98
Kumlu et al., 2003	13	W = 3.47 + 0.103T	0.99

n = no. data points, W = weight (g), T = time (day), r^2 = correlation coefficients

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